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6 Something to think with

Overview

Not everything has to be, or can be, carried in the head. Often, it is possible to give learners something which behaves a little like a memo or notepad. This chapter looks at some examples. In addition, analogies can be powerful devices for supporting productive thought. Thinking with the help of analogies is a natural process that even young children can handle, given certain conditions. In spite of this, many teachers ignore or neglect them. For this reason, analogies receive particular attention in this chapter. Various kinds of analogy and their uses are described. Although they are valuable possessions, their limitations must also be recognized.

Representations

Sometimes, what must be understood is demanding for the learner. It may, for example, take too much of the available mental resource to process, it may be too abstract or it may call for other knowledge and understanding which, at present, is beyond the reach of the learner. In short, the learner fails to build a working model – an internal representation – of what is to be understood in his or her head. But this does not mean understanding is impossible. We can often help learners by giving them something to think with. This something – an external representation – captures the essence of what is to be understood. It could, for instance, be something as simple as a gesture or movement or it could be a picture, a diagram or a chart. For example, very young children can interpret and use simple gestures to communicate and grasp thoughts (Trepanier-Street 2000). The human body can also be used as an aid to understanding with older children, as when we help them grasp the short amount of time that *Homo sapiens* has existed using someone with an outstretched arm. If the distance from the nose to the finger tip stands for one billion years, it would take more than four such people to show the age of the Earth but only a thin shaving of skin on the finger tip of one of them represents the duration of our existence (Law 2003). Such representations are devices which enable the learner to see relationships more readily and make reasoning easier. The graphic organizer is an example of such devices.

Graphic organizers

The graphic organizer is a scaffold in the form of a picture, diagram or chart which guides the learner's thought. Pictures have been seen as worth a thousand words for centuries

and have been used to support classroom learning for a long time. Although not the first, Comenius' *Orbis sensualium pictus* (The World in Pictures) was particularly well-known and went through over a hundred editions over several centuries (Newton, D. 1990). Pictures, especially when simplified to emphasize relevant information, can provide a ready-organized mental model for the learner to manipulate. For example, 4, 5 and 6-year-olds heard a story about *How Rosie Rabbit Almost Looked Over the Hedge*. This was a tale about a rabbit whose field was cluttered with the farmer's rubbish. The initial arrangement of the objects and the subsequent action which involved their re-arrangement were described. If the child did not adequately represent the initial situation in working memory, a relevant updating of it would be unlikely as the action progressed. In short, such children would not understand the subsequent action of the story. This was found to be the case for the overwhelming majority of those tested. However, when another group was shown a picture of the initial situation briefly at the beginning of the story, the overwhelming majority of these children were able to demonstrate an understanding of the subsequent action through to the end of the story. Having a clear, well-founded mental representation of the starting point of an event is likely to support appropriate updating or manipulation of that representation subsequently (Newton, D. 1994b). Describing how brakes worked for older learners, Mayer (1989) supplemented the account with diagrams showing the brakes in the on and off position. He also used a block diagram to depict the nitrogen cycle, the continuous flow of atmospheric nitrogen through animals, plants and the soil and back to the air. The effect was to improve conceptual recall by as much as 144 per cent. Creative problem solving was improved by as much as 460 per cent. Mayer saw good organizers as those which guide attention to what matters, highlighting internal relationships in the information and helping the learner construct external connections with existing knowledge. Flow and other processes and attributes, however, may have to be represented by pictorial metaphors, such as arrows, whiz lines, jagged and wavy lines. Care is needed, especially with younger learners, as these are not always understood as intended and some graphics, such as graphs and maps, can themselves present difficulties (Newton, D. 1985, Gerber *et al.* 1995). Nevertheless, teachers are well-placed to construct and try organizers to suit specific situations for themselves.

Having learners construct their own depictions of relationships has also been found to support understanding (Edens and Potter 2001), even with very young children (Scripp 2000). Constructing a concept or mind map to bring together and relate ideas in various ways has a similar effect (Mintzes *et al.* 1997, Bolte 2006). For instance, 'Recycling' may appear at the centre of a page, surrounded and connected to associated concepts, such as, 'Environmental' and 'Resources'. Each of these, in turn, may have ideas connected to it, in this way forming a web or network of related ideas. There are various versions of such representations. For example, Bulgren and Scanlon (1998) describe a 'concept diagram' for Settlers. There is a space for the learner to list key words, a space for the central concept (Settlers) and for the superordinate concept (People), lines for the attributes shared by all settlers, lines for those shared by some, and lines for those never present. Areas are set aside for the listing of specific examples, tied to the attributes, and for a definition of the term Settler. The student's task is to supply the information. Roth (1997) reminds us of the use of flowcharts, rather like cartoon strips, to sequence procedures.

Boyle and Yeager's study guides for whole topics provide a more extensive framework to support learning. They comprise the objectives, the reading that has to be done, key words, a list of activities, and some guidance on self-assessment. Story maps, on the other hand, are rather like concept maps which connect the setting (characters, time and place), problem, goal, action, and resolution. Such maps could be applied in other areas to connect important events, main ideas, other significant ideas and the outcome (Boyle and Yeager 1997). The long-term aim is for students to construct graphic organizers themselves but some may be so cumbersome or limited in use that students are unlikely to use them unprompted.

The philosopher, Ludvig Wittgenstein, talked of the mediated mind in which thought and someone's verbal expression of it are mutually reinforcing (Wittgenstein 1958, Nyíri 2005). Graphical organizers are able to extend thought outside the head in a similar way so that an understanding may be constructed or improved as the representation is constructed. They can also help the learner make connections by guiding attention to what is relevant. Some of the mental burden may be reduced as every detail need no longer be held in working memory.

Representations of concepts, patterns and relationships can, of course, involve more than pictures. They can be found in any subject and appear frequently in mathematics, science and technology. An iceberg model has been used to describe the way students' understanding of formal notations in mathematics (e.g. $\frac{3}{4}$) needs to rest on a large amount of experience with other representations (such as three quadrants of an apple and three out of four coins of the same denomination) (Webb *et al.* 2008). Representations can be quite concrete and tied to familiar experience. Resting on these may be structures designed to help learners grasp an operation and work with it. Harries *et al.* (2008), for instance, have designed an array of discs to illustrate fundamental properties of multiplication and show the process on a computer screen (see also Harries and Barmby 2007). These underlying representations are, ultimately, determined by the teacher. Chemistry, on the other hand, rests on a mastery of three particular kinds of representation: the macro (the properties of substances), the sub-micro (the behaviour of the basic particles in substances), and the symbolic (involving precise relationships in chemical changes) (Gilbert and Treagust 2009). At times, the sub-micro representation is presented as a three-dimensional model. In technology, a tangible model can be useful in problem solving both in supporting an understanding of the problem and in producing tentative solutions. Nevertheless, do not expect young children to model problems or potential solutions unprompted; they need to learn how to do it and find that the activity has value (Newton, D. 2005). In science, although representations do widely support understanding, they need careful handling as they can be misinterpreted (Chandrasegaran *et al.* 2009, Ainsworth 2008). In mathematics, many recommend that formal notation should rest on multiple representations, some drawn from everyday life, if it is to have meaning. Some representations in mathematics, however, are not self-evident (Nunes 1993). The meaning and use of a number line or a multiplication array, for instance, needs to be taught and practised and can still be difficult to grasp for some learners (Harries and Barmby 2007). Harries and Barmby point to the need for consistency and transparency in

how a representation is used so that learners can grasp its meaning. Brenner *et al.* (1997) showed the value of having learners represent a problem in several different ways (words, tables, graphs and symbols) before attempting its solution.

Analogies

An analogy draws parallels between what is to be understood and something familiar which looks or behaves similarly. For example, in electronics, certain components behave like gates that open when the conditions are right. Real gates are what we find in gardens and fields, not computers. They come from a different domain to the world of electronics but, nevertheless, the parallels can help us understand the function of certain electronic components. The gate is an analogous structure or an analogy for the component. Similarly, a narrow beam of light reflects off a mirror something like a ball bouncing off a wall. Ball-bouncing belongs to a different domain to light-reflecting but its action parallels that of light enough to make it useful in explaining reflection from a mirror. Someone who grasps these parallels has a potentially useful mental representation.

An analogy is intended to support the process of reasoning by using a parallel situation. Because it resembles or behaves like what is to be learned in some way, it offers a mental model to think with (Gentner 1998), allowing knowledge in one domain to be used in another. In effect, it bridges the gap between the known and the unknown (Halpern *et al.* 1990). For instance:

- in psychology the telephone exchange was once a common analogy used to explain the functions of the brain. Nowadays, it is not uncommon for the computer to have that role;
- in biology, the baking of a cake has been an analogy for photosynthesis;
- in archaeology, the process of excavation has been likened to eating a trifle – it is destructive;
- in literature, Tolstoy's *War and Peace* compared the French Army to a herd of cattle trampling the fodder that might have saved it from starvation;
- in language, the pronunciation and inflexion of parts of speech often takes the form of similar, known words; we notice this particularly in young children – 'I didded it' – but it is not confined to them;
- in environmental studies, the Earth may be compared to Easter Island where overpopulation and exploitation led to societal collapse;
- analogies themselves have been described as families of resemblances.

Thinking and communicating through parallels is something we do readily (Goswami 1992). Metaphors serve a similar purpose in enabling us to think of one thing in terms of something else. For instance, we might describe the skeleton of a building, feet like lead, or feeling woolly-headed. Literary devices like these catch attention and make a point. As Samuel Johnson (1709–1784) put it, metaphor and simile give you two ideas for one and convey meaning with a perception of delight.

At the same time, analogies are not always appropriate. For example, Campbell (1990) has questioned the use of oral language as an analogy for the acquisition of written language skills. Similarly, Thomas (1991) urges caution in drawing analogies between art in different domains, as between a play and a painting.

The effect of analogies

Analogies work because they facilitate the transfer of relationships from the known to the unknown (Halpern *et al.* 1990), as in Figure 6.1. This looks like a mentally demanding task and Piagetian psychologists considered reasoning by analogy to develop after about 11 or 12 years of age, when there was some facility with formal operations and correlational reasoning (Zeitoun 1984). Consequently, analogies have tended to be ignored as support for younger children's thinking. Goswami (1992), however, demonstrated that younger children are capable of analogical reasoning. For instance, children were shown pictures of a ball of playdoh before and after it was cut. Another picture showed an apple. Children readily reasoned analogically and, from pictures of a cut cake, a bruised apple, a ball, a banana and a cut apple, chose the cut apple as the matching one for the playdoh.

<<approximate position of Figure 6.1>>

Goswami found that primary school children could cope with such tasks provided that they know what is expected of them and they understand the basis of the analogy. Problems can stem from a lack of knowledge of the analogical base and relationships with the target. Bearing in mind that analogical reasoning is bridging between known and unknown, this is not unreasonable. There can be no analogical reasoning if the analogical model is not known.

Hatano and Inagaki (1994) observed 5-year-olds using the needs of people as an analogy for the needs of plants. The reasoning went something like this. Plants have to be watered. Why? People need water; plants need water; they have to have a regular drink just as people do. Why do plants die if you give them too much water? If people were to drink too much, they would be ill, fall down and die. It is the same with plants. Similarly, they found 6-year-olds were able to explain a squirrel's sickness, weakness and the effects of old age by analogy with people. Gelman and Markman (1987) noted simple analogical reasoning as early as 3 and 4 years of age. Young children can also generate their own parallels. For example, one 6-year-old was able to depict the tune of 'Row, Row, Row Your Boat' using spaced lines of different lengths to represent phrase structure, rhythm and pitch (Davidson and Scripp 1992).

The key to success is that what will serve as the analogical model is well-known to the learner. The limited experience of young children means that there may be only a small pot of knowledge to draw on. However, the difficulty may be overcome by ensuring that

the requisite knowledge is present. Newton, D. and Newton, L. (1995) showed that spending a few minutes raising 6-year-olds' awareness of the flow of water when pumped through a tube by a soap dispenser makes it possible to use this as an effective analogy for teaching about simple electrical circuits (Figure 6.2).

<<approximate position of Figure 6.2>>

Subsequent tests showed that the children could use this analogy to explain what happened in other electrical circuits. One child described the parallels in the following terms:

Child: It's [electricity's] just ... kind of ... a bit like water. It's just going round and into the bulb.

Investigator: What? The electricity's like water?

Child: Yes.

Investigator: How's the electricity like water?

Child: Because, with the pump, you press that and the water goes round but that goes back to the bottle ... Like, say that was the light bulb and this was the battery. Press that ... Right? And it would go all into the battery.

When faced with a circuit which had two opposing batteries and a bulb that did not come on, he was spontaneously able to explain it in terms of two soap dispensers and the opposing flows they were trying to induce.

Analogies have also been used to develop young children's vocabulary in a variety of subjects. Greenwood (1988) has pointed out that learning a list of words is a decontextualized task which risks acquired only vague meanings. Analogy exercises, on the other hand, provide a context and require the learner to engage mentally with the meaning. For example, *book is to read as television is to ...* provides a context to explore a variety of words of like meaning (HuffBenkoski and Greenwood 1995). In music, inexperienced learners often lack a vocabulary for describing musical experience. Once again, analogy can help. For example, it might be spatial, as in using *up* and *down* to describe changes in pitch, or *figure* and *ground* to distinguish a musical element from its context (Froehlich and Cattley 1991, Stollack and Alexander 1998).

Analogies are not always effective, as when the topic is readily understood without support or when the analogy is a bad one. Analogies may also be ineffective when the learner does not grasp the analogy or see it as relevant or simply does not use it. For example, Gilbert (1989) found little evidence of support when using an analogy in biology units for 14 and 15-year-olds. His analogy for a foetus being sustained in the womb was an electrical appliance plugged into a socket in the wall. The placenta was described as being like the wall and socket and the umbilical cord as being like the electrical cable. Just as electrical current flows from the socket to the appliance, so food and minerals flowed to the foetus. However, his analogy may not have been necessary, it may not have been good enough, or may be rendered worthless by the instructional

demand it added to the task. In this instance, it seems likely to have been the first of these, the topic was readily grasped without it.

Kinds of analogy

Analogies may be classified in a variety of ways. For example, Thiele and Treagust (1994) classified them as *simple*, *enriched* or *extended*. Simple analogies were those which were statements without elaboration (for example, the spinal cord is like a cable). Enriched analogies included the grounds for the analogy (for example, wind carrying sand acts like a sandblasting machine; sandblasting machines blow sand at stonework to wear away the dirty surface). Extended analogies apply to several topics (for example, atoms as billiard balls occur in several topics in several sciences).

Curtis and Reigeluth (1984) classified analogies into those that are *structural*, those that are *functional* and those that are both *structural and functional*. With structural analogies, parallels are drawn between appearances, physical organizations, or structures (for example, *the Earth is like an orange*; both appear roughly spherical with a slightly roughened surface and both have ‘skins’). With functional analogies, parallels are drawn with the way something operates, behaves or functions (for example, *the brain is like a computer*; both have means of encoding incoming information, processing and storing it). Some analogies have both properties (for example, *the soap dispenser and tube analogy for an electrical circuit* can resemble *and* behave like some aspects of a simple electrical circuit; the dispenser can look a little like a battery, the tube outwardly resembles a wire and water circulates through the dispenser and tube as an electrical current does through a battery and wire). Curtis and Reigeluth considered this kind of analogy to be particularly effective. It is easy to match the components and that makes it easier to see parallels in the way they function.

The point is that one analogy can have a very different form from another and serve a different function. There is no reason to expect them to be equally effective in these functions and it is useful to know that functional analogies are potentially effective. At the same time, enriched analogies are likely to be more effective than simple analogies with younger children because the grounds for the analogy are made explicit.

Analogy and understanding

What is to be understood is often referred to as the *target*. The parallel situation which is to help understand the target is the analogue. Analogical mapping between target and analogue is performed to construct the analogy (Duit 1991). Consider what Curtis and Reigeluth called a structural analogy, such as an orange for the shape of the Earth. The intention is to support the understanding of appearance, organization or structure. The Earth is the target (T) and the orange is the analogue (A). Structural features can be mapped between the two:

T1: The Earth is roughly spherical;
 A1: The orange is roughly spherical.

T2: The surface of the Earth is uneven but this is insignificant on the larger scale;

A2: The surface of the orange is uneven but this is insignificant on the larger scale.

T3: The Earth has a crust;
 A3: The orange has a skin.

Because we tend to view the Earth from a local perspective, its spherical nature, the insignificance of its mountains and valleys, and the existence of an outer layer can be difficult to grasp. On the scale of an orange, it is easier. As far as these features are concerned, the orange provides a familiar model. The familiarity makes processing less demanding. At the same time, the model provides a mental structure which allows the relevant relationships to be readily inferred. The pores on its skin visibly and palpably do not present major interruptions to the surface so, on the same scale, the Earth's mountains and valleys could be no more significant. In effect, thinking is easier because the orange domain is more familiar and the relationships easier to understand in it.

In the case of a functional relationship, the function or behaviour of the target is modelled by the analogue. The computer as a model for the brain is an example. The brain does not look like the computer and may not be organized like it, nevertheless, they have some functions in common:

T1: encodes information from the senses for processing;
 A1: encodes incoming data for processing;

T2: holds and processes information in working memory;
 A2: holds and processes data in random access memory (RAM);

T3: stores information for later recall in long term memory;
 A4: stores information for later recall on a hard disc drive;

T4: communicates outcomes of processing (e.g. by speech or writing);
 A4: communicates outcomes of processing (e.g. by screen or printer).

On the assumption that the learner is familiar with the computer, these functional parallels provide a mental structure for the brain and allow some reasoning about the brain to take place with it. Thus, it is possible to exceed the RAM capacity of a computer so we can speculate about the same possibility with the working memory model.

Another functional example is when the target begins in one state and ends in another and the analogue models the change. One difficulty in understanding an event of this kind is in connecting one state with another. An analogy can help by providing an alternative, more familiar path between mental states drawing on known relationships (Figure 6.3). The situation has to be mentally represented but, instead of attempting to bridge from this to some subsequent state, it is mapped onto another representation (often recalled from memory). This other representation is then articulated according to familiar 'rules' to produce a subsequent state. This subsequent state is then translated into the target's subsequent state (Halford 1993).

For example, a ray of light changes direction when it travels from air into a block of glass (Figure 6.3). An analogy may be made with a pair of wheels on an axle which run into sand. The reason that the ray of light changes direction can be quite difficult to grasp. But, the reason for the wheels changing direction involves familiar concepts and experience. One wheel (X) enters the sand before the other. The drag of the sand slows it down but the other wheel is still off the sand and is going faster. This makes the axle slew around and travel in a different direction, much like the ray of light does. A significant amount of research relates to the use of analogy in supporting understanding of the natural and physical world and for those with a particular interest in this Duit (1991) and Duit and Glynn (1996) provide useful accounts.

<<Approximate position of Figure 6.3>>

It seems that the retrieval of the basis of an analogy it is not spontaneous, even in adults. When structures *and* functions of a target are modelled by an analogue, the two may be connected in many ways in a learner's memory. This probably increases the likelihood that the target will stimulate a recall of the analogue. It also makes the analogy potentially more powerful since there are more relationships to draw on (Suzuki 1994). There is, however, more to it than that. For instance, in the case of the *flow* of electricity, it is the correspondence with the *flow* of water that stimulates retrieval. Terms with related meanings may play a significant part in the retrieval process (Thagard 1992). In mapping, the structure of some existing knowledge is mapped onto the new or less understood target (Gentner 1989). When it comes to mapping, it is the existence of material correspondences and similar configurations that matter. In the electricity-water flow analogy, wires and tubes carrying the flow would be an instance.

In long explanations, analogies are more effective if presented at the outset (Halpern *et al.* 1990). Here, they can serve as an advance organizer, giving the student a mental framework to think with and fostering the construction of an appropriate mental representation. This is, of course, what Ausubel's (1968) comparative advance organizer does. It ensures that there is a sound basis to think from at the beginning of the instruction.

Halpern *et al.* (1990) also compared the relative merits of near and far analogies. Near and far analogies are drawn from similar and different domains, respectively. For

example, in an account of the lymph system, they used the movement of water through a sponge as the far domain analogy and the movement of blood through veins as the near domain analogy. The far analogies were more effective in promoting understanding, possibly because they are very unlike the topic under study so attract attention and tend to be recalled more readily. However, being distant, parallels may not be clear and the student may need to dwell on them to a greater degree.

Learners may, of course, generate their own analogies. The conditions for success are not necessarily like those for the analogy that is given. Wong (1993) found that students (adults in this case) can generate analogies when attempting to understand phenomena such as the behaviour of air in a bicycle pump. Analogy-making like this can add coherence and meaning and can help to develop understanding further. This makes the self-generated analogy a potentially useful device for supporting understanding but it assumes that the learner has some idea about what an analogy is. It also opens the possibility that inappropriate or weak analogies will be generated so that understanding may actually be hindered. When this is likely, it is important to discuss students' analogies as they generate them (Thagard 1992).

Bridging analogies

When some action or event is difficult to understand or when misconceptions lead to understanding failure, Clement (1993) has found bridging analogies to be helpful. For instance, he found students had difficulty accepting that a book on a table experiences an upward force from the table (called the reaction of the table). He constructed a chain of experiences intended to bridge from the known to the unknown (Figure 6.4).

<<Approximate position of Figure 6.4>>

To begin with, the student pushes down on the spring and can feel its response pushing up. This is repeated with a hand on a sponge, then a book replaces the hand and produces the same effect. There is an obvious effect on the hand from the spring. Although less, the effect from the sponge is still noticeable. Since the book depresses the sponge in the same way, it is reasonable to believe that there is an upward push on the book like that experienced by the hand. The book is now placed on a 'table' made from thin board. The 'table' is distorted just like the sponge. Again, it is reasonable to believe that there is an upward force on the book as there was when it was on the sponge. Finally, the book is placed on a real table. Although the depression is not noticeable, it can be made so by reflecting light from a mirror on its surface and watching the reflection as the book is placed on it. Since the real table is also depressed, it is again reasonable to believe that there is an upward force on the book.

The hand on the spring, sponge and thin board 'table' provide the analogies for the book on the real table. The sensation of a hand pushing down on the spring, sponge and thin board may not be in prior experience or may not be available for reflection. Providing the experience ensures that it is available and is in a useful context. At the same time, a feeling of the upward force is likely to be more directly meaningful than using a force

meter as an intermediary that requires interpretation. The problem is that, as with bridging explanations, bridging analogies can be difficult to construct for some topics. Most will have to be collected or compiled before teaching and, as they are topic specific, they will form a part of a teacher's subject-specific, pedagogical knowledge.

Using analogies to change perspectives

Having a particular view of the world shapes the relationships we are likely to infer. In this sense, understanding is perspective-bound (e.g. Wolpert 1992). Changing the perspective can enable new understandings. For instance, in 1615, William Harvey saw the heart in terms of a bellows-like water pump. This new perspective generated a new way of looking at the function of the heart and its vessels, namely, as a circulatory system (Sutton 1996). Students often need to adopt another or a particular perspective when approaching a topic in order to understand in the way that subject specialists do. Sutton argues persuasively that perspectives stem from the language, metaphors and analogies of a subject and novices need to assimilate them. In this way, other relationships are enabled through a changed perspective.

This is an important idea. The analogy can reduce processing load but, here, its primary function is as a provider of a new perspective. This perspective-changing role of analogy could play a significant part in enabling particular or authorized understandings in some subjects. Such analogies often stem from the person responsible for the particular perspective in the first place or from their apologists or popularizers. Darwin's Tree of Life analogy for evolutionary relationships amongst species is an instance. Rouvray (1994) describes the very important role of analogies in the development and progress of science. In particular, he mentions the billiard balls in a box analogy for a gas, beads on a string for polymer molecules, and the solar system for the atom. In such cases, the analogy may not be familiar to the student and would have to be developed through talk and experience. In other cases, metaphors and analogies become a mundane part of speech and lose their referent power, allusion and meaning. As such, they cease to support in the way they once did. Sutton (1996) feels that understanding is, in part, coming to know this analogical language as it was intended.

Limitations of support from analogies

Supporting understanding with analogies is not without its difficulties. One of these is when the learner does not know the analogical situation well enough to make it immediately useful. A solution is to teach it thoroughly before using it. The less experienced the learner, the more likely this course of action will be needed. In general, it could be good practice to check existing knowledge, if only to bring it to consciousness ready for use.

Analogies are also not without shortcomings. The main one is that no analogy is a perfect match for the target knowledge. This means that there is a danger that an analogy will be over-extended and inappropriate aspects will be given to the target. In the electricity-

water analogy, when the tube is cut, water runs out. It would not be appropriate to transfer this to the electrical circuit: electricity does not flow from a cut wire. One approach to the danger of over-extension is to make limitations explicit (Heywood and Parker 1997).

There is also an order effect which may block alternative interpretations of events (Keane 1997). An example is when someone learns British history before American history. This tends to make British history the source of models for American history, rather than the other way around. Keane describes the way politicians use the order effect to their advantage. By drawing an analogy between the drug problem and fighting a war, for instance, people tend to think of solutions based on police action and penal legislation rather than alternatives, perhaps based on an 'illness-of-society' analogy.

Analogies are, of course symmetrical: water flow in pipes could be an analogy for electrical current flow and electrical current flow could be a model for water flow in pipes. In practice, the one generally found to be difficult to understand tends to be the target. However, a good analogy is not available until its source is known to the learner. This means there may need to be some long term planning to develop a source before the target arises.

Preparing to offer an analogy

Generally, Treagust *et al.* (1992) found that analogy use in teaching tends not to be pre-planned but is a response to non-verbal cues. Analogies in lessons were rare and not used to their best effect. Curtis and Reigeluth (1984) analysed North American science textbooks and found them to be relatively rare (8.3 analogies per book). Newton, L. (2003) came to a similar conclusion for primary science textbooks in the U.K. The incidence of analogies can also vary enormously within and between subjects. For instance, Curtis (1988) found that there were about three times as many analogies in science texts as in social studies in the U.S.A. On the basis of what has been discussed, some more or less self-evident steps for teaching with analogy can be offered:

1. Check the student's prior knowledge of the topic to determine if support for understanding is needed.
2. If the topic is demanding, look for a stock analogy in books and by asking colleagues.
3. If one is not available, construct an analogy, preferably based on something known to the learner. This may not be easy but can be rewarding.
4. If the analogy is not well known, provide experience of it before using it.
5. Introduce the analogy early in the teaching.
6. Exemplify its application.
7. Identify its limits.
8. Provide practice in using the analogy.

Summary

The aim of these supporting devices is to help people see what matters, notice relationships, build their own internal, mental representations and think productively with them. They have a variety of shapes and sizes, including an enactive gesture, a pictorial depiction, an artefact, a computer micro-world and an analogy. Each more or less represents what we want someone to grasp. Analogies support understanding because they enable reasoning about something relatively unknown through something generally well-known. The links between some representations and what is to be understood are not necessarily evident to a learner and may have to be taught. The limitations of such representations need to be made explicit. In the next chapter, various ways of supporting understanding are brought together and illustrated in the context of the surrogate teacher.

Afterthought

Students have been described as customers. After all, students in higher education and elsewhere often pay for their education. How might such an analogy with commerce shape notions of teaching and learning?